As described in Section 7.11, this addendum presents the evaluation of potential groundwater impacts to the Coldwater Creek located adjacent to the east of Sub-area 6D. Figure 1 presents a schematic cross-section. This evaluation was performed in accordance with the procedures included in the MRBCA program and verbal discussions with Rich Nussbaum and John Hoke of MDNR on October 7, 2004. This addendum includes:

- Selection of constituents of concern (COCs),
- Stream classification and beneficial use,
- Water quality criteria for COCs,
- Back-calculation of allowable groundwater concentrations at the sampling points in Sub-area 6D,
- Calculation of representative groundwater concentrations,
- Comparison of the representative concentrations with the allowable concentrations, and
- Conclusions of this analysis.

1.0 SELECTION OF CONSTITUENTS OF CONCERN

Table 1 presents the list of constituents detected in groundwater samples at various distances from the Coldwater Creek. In all 28 constituents were detected in groundwater about 2,000 feet from the Creek, 14 constituents at 1,000 ft from the Creek, and only 11 constituents at 75 ft from the Creek. Several of the constituents detected at 2,000 ft from the Creek were not detected in sampling points close to the Creek. Conservatively, all the 28 constituents detected at 2,000 ft from the Creek were evaluated.

2.0 STREAM CLASSIFICATION AND BENEFICIAL USE

As per Table H of 10 CSR 20-7.031 (MDNR, August 31, 2000), the portion of the Coldwater Creek adjacent to the east of Sub-area 6D is an unclassified stream (Class U). As per communication with John Hoke of MDNR (October 7, 2004), general warm-water fishery was considered as the beneficial use for the Coldwater Creek adjacent to the Sub-area 6D. The downstream portion of the Coldwater Creek from Hwy. 67 to Missouri River is classified as a Class C stream. Table H of 10 CSR 20-7.31 provides the following beneficial uses for the downstream portion of the Coldwater Creek (Class C):

- Protection of warm water aquatic life,
- Human health – fish consumption, and
- Livestock & wildlife watering.

3.0 WATER QUALITY CRITERIA

As per MDNR, water quality criteria depend on the stream classification and beneficial use. For an unclassified stream, acute water quality criteria has to be met at the point of groundwater discharge. Further at the point the unclassified stream becomes a classified stream, chronic water quality criteria has to be met.

The acute and chronic water quality criteria for COCs were obtained from Table A of 10 CSR 20-7.031 and are presented in Table 2.

Note that acute criteria are available for only arsenic, cadmium, chromium, lead, and mercury. For this evaluation conservatively the most protective criteria (for various levels of water hardness) was selected and is tabulated in Table 2.

The chronic criteria also depend on the beneficial use designations of the stream. For the three beneficial uses presented in Section 2.0, the most stringent criteria are shown in Table 2. Typically, the chronic criteria are lower (more stringent) than the acute criteria.

4.0 BACK-CALCULATION OF ALLOWABLE GROUNDWATER CONCENTRATIONS

The allowable groundwater concentration at the sampling points located 75 ft from the Creek were calculated using:

$$C_{all} = DAF_{sat} \times C_{wqc} \quad (1)$$

where,

C_{all}	=	Allowable groundwater concentration (µg/L),
DAF_{sat}	=	Dilution attenuation factor (DAF) in saturated zone (unitless), and
C_{wqc}	=	Water quality criteria (µg/L).

To calculate the DAF between the on-site groundwater area and the point of discharge (a distance of 75 ft), Domenico's steady state model as implemented in the MRBCA program was used. The input parameters used to estimate the DAF are shown in Table 3 (Domenico and Schwartz, 1990).

Conservatively, it was assumed that there is no biodegradation. The back-calculated allowable concentrations in groundwater 75 ft upgradient of the point of discharge using acute water quality criteria and chronic water quality criteria are presented in Table 2.

5.0 CALCULATION OF REPRESENTATIVE GROUNDWATER CONCENTRATIONS

Tables 4 and 5 also present a comparison of the back-calculated allowable concentration with the representative groundwater concentrations 75 ft upgradient from the Creek. Specifically, representative concentrations are the average concentrations in MW6. Note non-detect values were replaced with half the detection limit.

6.0 COMPARISON OF THE REPRESENTATIVE CONCENTRATIONS WITH THE ALLOWABLE CONCENTRATIONS

Table 4 compares the representative concentrations with the allowable groundwater concentrations protective of the acute criteria. None of the COCs exceed the criteria. For an unclassified stream, this is the primary criteria that have to be satisfied at the point of discharge.

Table 5 presents a comparison of the back-calculated groundwater concentrations based on meeting the chronic criteria at the point of discharge with the representative concentrations. Table 5 shows that the criteria are exceeded for chromium and lead by 11 and 45 %, respectively. However, these small exceedences are not of concern because the chronic criteria have to be met

at the point where the Creek changes designation from a Class U to a Class C. This is about 3.5 miles downstream and over this distance the incremental concentration of constituents in the stream would decrease due to a variety of natural attenuation processes.

7.0 CONCLUSIONS

Based on the above screening level conservative evaluation, it can be concluded that the discharge of groundwater from Sub-area 6D into the Coldwater Creek meets the water quality standards.

8.0 REFERENCES

Domenico, P.A., and Schwartz, F.W., 1990. Physical and Chemical Hydrogeology. John Wiley and Sons, NY, p. 824 (Eqn. 17.21).

MDNR, August 31, 2000. Rules of Department of Natural Resources Division 20 – Clean Water Commission Chapter 7 – Water Quality.

Table 1
Constituents Detected in Groundwater at Various Distances from the Coldwater Creek
Boeing Tract 1, St. Louis, Missouri

Constituents	Distances from the Coldwater Creek		
	2,000 ft	1,000 ft	75 ft
1,1-Dichloroethane	X		
1,1-Dichloroethene	X		X
1,1,2-Trichloro-1,2,2-trifluoroethane	X		
1,2,4-Trimethylbenzene	X		
1,2-Dichlorobenzene	X		
1,2-Dichloroethene (total)	X	X	
1,3-Dichlorobenzene	X		
1,4-Dichlorobenzene	X		
Arsenic	X	X	X
Barium	X	X	X
Benzene	X	X	
Bromodichloromethane	X		
Cadmium	X	X	X
Chloroform	X		
Chromium	X	X	X
cis-1,2-Dichloroethene	X	X	X
Dichlorodifluoromethane	X		
Lead	X	X	X
Mercury	X	X	X
Methyl tert-butyl ether	X		
Methylene chloride	X		
set-Butylbenzene	X		
Tetrachloroethene	X		X
Toluene		X	X
TPH (GC/FID) high fraction	X	X	
trans-1,2-Dichloroethene	X	X	
Trichloroethene	X	X	X
Trichlorofluoromethane	X		
Vinyl chloride	X	X	
Total No. of Con	**28**	**14**	**11**

Notes:
Samples at 2,000 ft away from the Coldwater Creek included sampling points B28MW1, B28MW2, MW3A, MW3B, MW3, MW7, RC3, RC6S, and RC7.
Samples at 1,000 ft away from the Coldwater Creek included sampling points B27E11, B27E5, B27E6, B27E7, B27E8, MW5AS, MW5BS, MW5CS, and MW8AS.
Samples at 75 ft away from the Coldwater Creek included sampling point MW6.

Table 2
Water Quality Criteria for Constituents of Concern
Boeing Tract 1, St. Louis, Missouri

Constituents	Water Quality Criteria (ug/L)		Allowable Groundwater Concentration (ug/L)*	
	Acute	Chronic**	Acute	Chronic
1,1-Dichloroethane	---	---	---	---
1,1-Dichloroethene	---	3.2	---	5.33
1,1,2-Trichloro-1,2,2-trifluoroethane	---	---	---	---
1,2,4-Trimethylbenzene	---	---	---	---
1,2-Dichlorobenzene	---	---	---	---
1,2-Dichloroethene (total)	---	---	---	---
1,3-Dichlorobenzene	---	---	---	---
1,4-Dichlorobenzene	---	---	---	---
Arsenic	20	---	33.3	---
Barium	---	---	---	---
Benzene	---	71	---	118
Bromodichloromethane	---	---	---	---
Cadmium	31	9.1	51.7	15.2
Chloroform	---	---	---	---
Chromium	62	42	103	70.0
cis-1,2-Dichloroethene	---	---	---	---
Dichlorodifluoromethane	---	570,000	---	950,190
Lead	63	9	105	15.0
Mercury	2.4	0.5	4.00	0.83
Methyl tert-butyl ether	---	---	---	---
Methylene chloride	---	1,600	---	2,667
set-Butylbenzene	---	---	---	---
Tetrachloroethene	---	9	---	15.0
Toluene	---	200,000	---	333,400
TPH (GC/FID) high fraction	---	---	---	---
trans-1,2-Dichloroethene	---	140,000	---	233,380
Trichloroethene	---	80	---	133
Trichlorofluoromethane	---	860,000	---	1,433,620
Vinyl chloride	---	525	---	875

Note:

---: Water quality criteria not available as per Table A of 10 CSR 20-7.031

*: These concentrations have to be met at 75 ft upgradient of the point of discharge.

**: These concentrations have to be met where the Coldwater Creek becomes a classified stream at least 500 ft downstream of the point of discharge.

Table 3

Input Parameters Used to Estimated Dilution Attenuation Factor

Boeing Tract 1, St. Louis, Missouri

Parameter	Value	Unit
Distance from the edge of on-site groundwater area to the point of discharge	75	ft
Dimension of on-site groundwater area perpendicular to the groundwater flow direction*	84	ft
Lateral dispersivity (1/30 of distance)	2.5	ft
Vertical dispersivity (1/200 of distance)	0.375	ft

Note:

*: Distance between sampling points B27E12 and MW6

Table 4
Comparison of Representative Groundwater Concentrations with Acute Water Quality Criteria
Boeing Tract 1, St. Louis, Missouri

Sample ID	Date	Arsenic	Cadmium	Chromium	Lead
MW6W	07/27/00				
MW6W	01/09/01				
MW6W	05/08/01				
MW6W	07/19/01				
MW6W	10/25/01				
MW6W	03/06/02				
MW6W	05/31/02				
MW6W	08/14/02				
MW6W	12/06/02				
MW6W	03/13/03				
MW6W	06/20/03				
MW6W	07/27/00	17.3	< 5	146	39.2
MW6W	01/09/01	< 50	< 10	170	< 50
MW6W	05/08/01	17	4.3	50	31
MW6W	07/19/01	< 5	< 2	4.2	< 5
MW6W	10/25/01	< 5	< 2	18	11
Representative Concentration		**12.9**	**2.76**	**77.6**	**21.7**
Allowable Concentration (Acute Criteria)		**33.3**	**51.7**	**103**	**105**
Exceed/Not Exceed		**Not Exceed**	**Not Exceed**	**Not Exceed**	**Not Exceed**

Notes:
All concentrations in ug/L (micrograms per liter)
< Less than detection limit shown
Blanks: Not analyzed
For non-detects, half the detection limit was used for average calculation.

Table 5
Comparison of Representative Groundwater Concentrations with Chronic Water Quality Criteria
Boeing Tract 1, St. Louis, Missouri

Sample ID	Date	1,1-Dichloro ethene	Cadmium	Chromium	Lead	Tetrachloro ethene	Toluene	Trichloro ethene
MW6W	07/27/00	J 0.35				7.7	< 1	3.9
MW6W	01/09/01	< 5				8	< 5	< 5
MW6W	05/08/01	< 1				11	2	3.3
MW6W	07/19/01	< 1				8.2	< 5	2.9
MW6W	10/25/01	< 1				HJ3 10	< 5	H 3.6
MW6W	03/06/02	< 1				9.3	< 5	4.1
MW6W	05/31/02	< 1				H 7.9	< 5	H 2.2
MW6W	08/14/02	< 1				8.4	< 5	2.4
MW6W	12/06/02	< 1				11	< 5	3.6
MW6W	03/13/03	< 1				7.4	< 5	2.5
MW6W	06/20/03	< 1				J4 12	< 5	J4 2.4
MW6W	07/27/00		< 5	146	39.2			
MW6W	01/09/01		< 10	170	< 50			
MW6W	05/08/01		4.3	50	31			
MW6W	07/19/01		< 2	4.2	< 5			
MW6W	10/25/01		< 2	18	11			
Representative Concentration		**0.67**	**2.76**	**77.6**	**21.7**	**9.17**	**2.27**	**3.04**
Allowable Concentration(Chronic Criteria)		**5.33**	**15.2**	**70.0**	**15.0**	**15.0**	**333,400**	**133**
Ratio of Representative Conc. to Allowable Conc.		**0.13**	**0.18**	**1.11**	**1.45**	**0.61**	**0.00001**	**0.02**
Exceed/Not Exceed		**Not Exceed**	**Not Exceed**	**Exceed**	**Exceed**	**Not Exceed**	**Not Exceed**	**Not Exceed**

Notes:
All concentrations in ug/L (micrograms per liter)
< Less than detection limit shown
Blanks: Not analyzed
For non-detects, half the detection limit was used for average calculation.

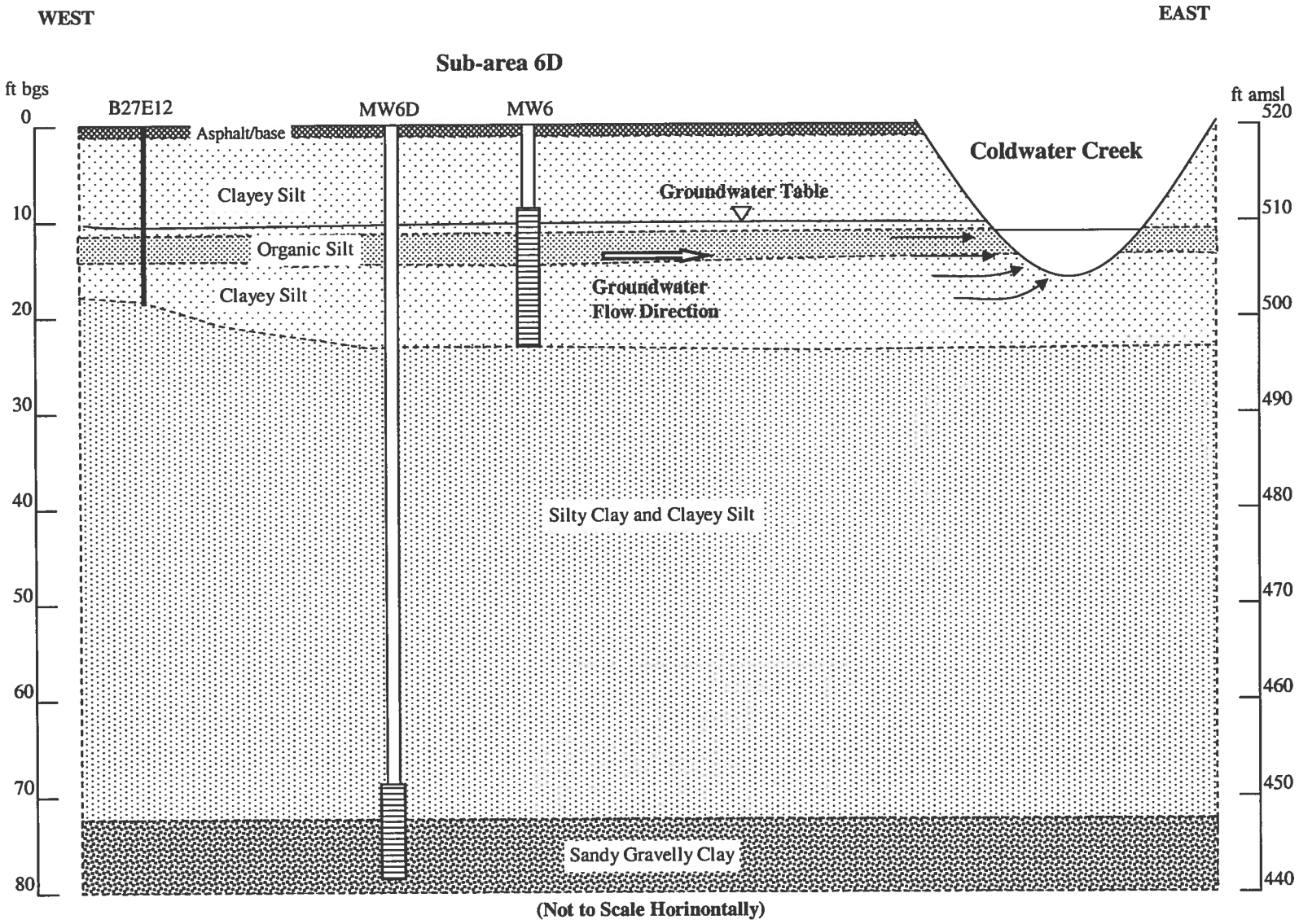

Figure 1. Schematic Cross Section Showing Sub-area 6D and the Coldwater Creek Boeing Tract 1, St. Louis, Missouri